

## General Description

The 5T9304 differential clock buffer has a user-selectable differential input to four LVDS outputs. The fanout from a differential input to four LVDS outputs reduces loading on the preceding driver and provides an efficient clock distribution network. The 5T9304 can act as a translator from a differential HSTL, eHSTL, LVEPECL (2.5V), LVPECL (3.3V), CML, or LVDS input to LVDS outputs. A single-ended 3.3V / 2.5V LVTTTL input can also be used to translate to LVDS outputs. The redundant input capability allows for an asynchronous change-over from a primary clock source to a secondary clock source. Selectable reference inputs are controlled by SEL.

The 5T9304 outputs can be asynchronously enabled/disabled. When disabled, the outputs will drive to the value selected by the GL pin. Multiple power and grounds reduce noise.

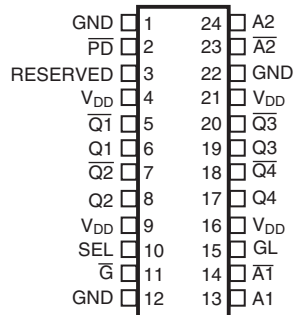
## Applications

- Clock distribution

## Features

- Guaranteed low skew: 50ps (maximum)
- Very low duty cycle distortion: 125ps (maximum)
- Propagation delay: 1.75ns (maximum)
- Up to 450MHz operation
- Selectable inputs
- Hot insertable and over-voltage tolerant inputs
- 3.3V/2.5V LVTTTL, HSTL eHSTL, LVEPECL (2.5V), LVPECL (3.3V), CML or LVDS input interface
- Selectable differential inputs to four LVDS outputs
- 2.5V V<sub>DD</sub>
- 0°C to 70°C ambient operating temperature
- Available in lead-free (RoHS 6) package
- 

## Pin Assignment



**5T9304**

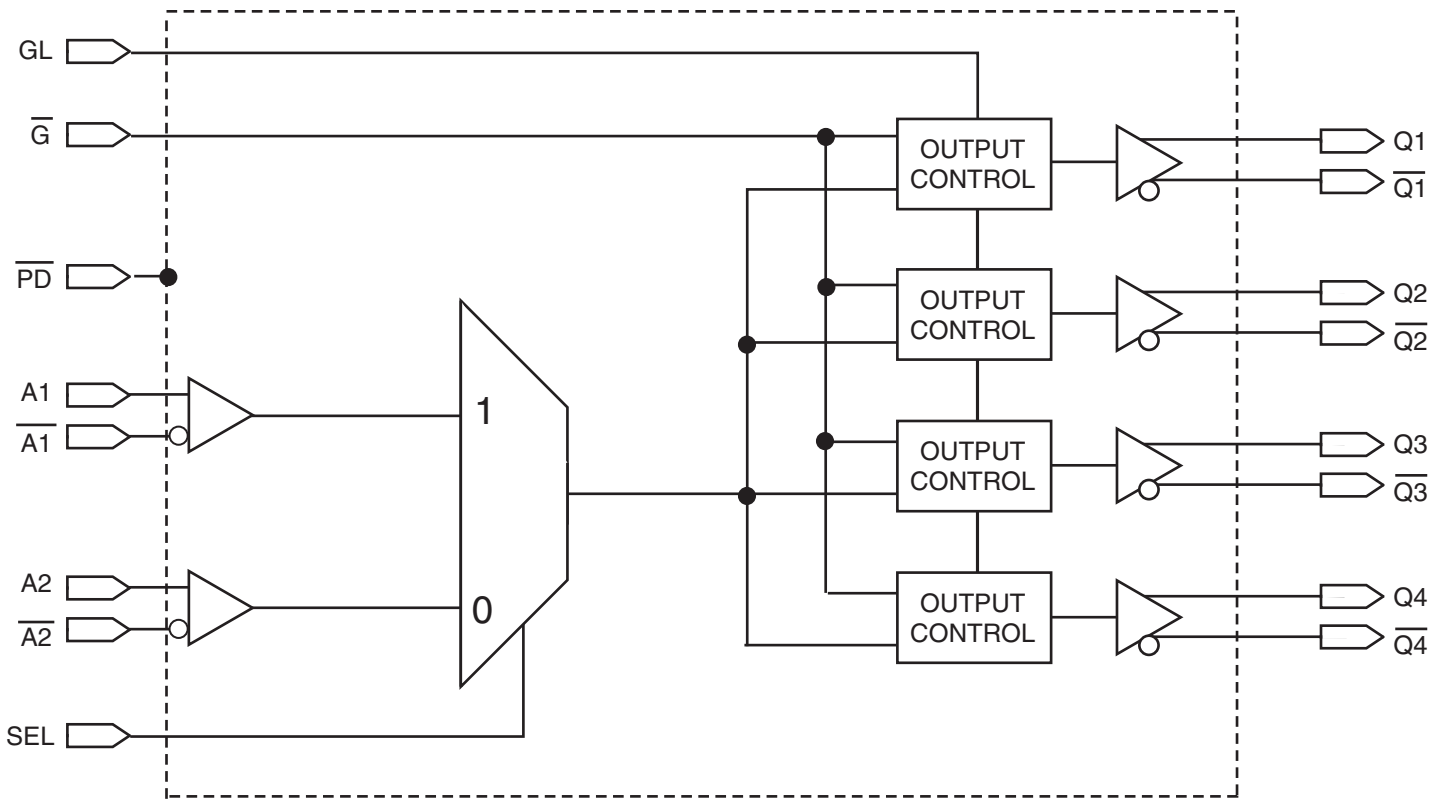
**24-Lead TSSOP**

**4.4mm x 7.8mm x 1.0mm package body**

**G Package**

**Top View**

### Block Diagram



**Table 1. Pin Descriptions**

Number	Name	Type		Description
1, 12, 22	GND		Power	Power supply return for all power.
2	$\overline{\text{PD}}$	Input	LVTTL	Power-down control. Shuts off entire chip. If LOW, the device goes into low power mode. Inputs and outputs are disabled. Both Qx and $\overline{\text{Qx}}$ outputs will pull to VDD. Set HIGH for normal operation. <sup>(3)</sup>
3	RESERVED	Reserved		Reserved pin.
4, 9, 16, 21	V <sub>DD</sub>		Power	Power supply for the device core and inputs.
5, 7, 18, 20	$\overline{\text{Q1}}, \overline{\text{Q2}}, \overline{\text{Q4}}, \overline{\text{Q3}}$	Output	LVDS	Complementary differential clock outputs.
6, 8, 17, 19	Q1, Q2, Q4, Q3	Output	LVDS	Differential clock outputs.
10	SEL	Input	LVTTL	Reference clock select. When LOW, selects A2 and $\overline{\text{A2}}$ . When HIGH, selects A1 and $\overline{\text{A1}}$ .
11	$\overline{\text{G}}$	Input	LVTTL	Gate control for differential outputs Q1 and $\overline{\text{Q1}}$ through Q4 and $\overline{\text{Q4}}$ . When $\overline{\text{G}}$ is LOW, the differential outputs are active. When $\overline{\text{G}}$ is HIGH, the differential outputs are asynchronously driven to the level designated by GL <sup>(2)</sup> .
13, 24	A1, A2	Input	Adjustable <sup>(1, 4)</sup>	Clock input. A[1:2] is the "true" side of the differential clock input.
14, 23	$\overline{\text{A1}}, \overline{\text{A2}}$	Input	Adjustable <sup>(1, 4)</sup>	Complementary clock inputs. $\overline{\text{A[1:2]}}$ is the complementary side of A[1:2]. For LVTTL single-ended operation, $\overline{\text{A[1:2]}}$ should be set to the desired toggle voltage for A[1:2]: 3.3V LVTTL VREF = 1650mV 2.5V LVTTL VREF = 1250mV
15	GL	Input	LVTTL	Specifies output disable level. If HIGH, Qx outputs disable HIGH and $\overline{\text{Qx}}$ outputs disable LOW. If LOW, Qx outputs disable LOW and $\overline{\text{Qx}}$ outputs disable HIGH.

## NOTES:

- Inputs are capable of translating the following interface standards:  
Single-ended 3.3V and 2.5V LVTTL levels  
Differential HSTL and eHSTL levels  
Differential LVEPECL (2.5V) and LVPECL (3.3V) levels  
Differential LVDS levels  
Differential CML levels
- Because the gate controls are asynchronous, runt pulses are possible. It is the user's responsibility to either time the gate control signals to minimize the possibility of runt pulses or be able to tolerate them in down stream circuitry.
- It is recommended that the outputs be disabled before entering power-down mode. It is also recommended that the outputs remain disabled until the device completes power-up after asserting  $\overline{\text{PD}}$ .
- The user must take precautions with any differential input interface standard being used in order to prevent instability when there is no input signal.

**Table 2. Pin Characteristics** (T<sub>A</sub> = +25°C, F = 1.0MHz)

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C <sub>IN</sub>	Input Capacitance			3		pF

NOTE: This parameter is measured at characterization but not tested.

## Function Tables

**Table 3A. Gate Control Output Table**

Control Output		Outputs	
GL	$\overline{G}$	Q[1:4]	$\overline{Q[1:4]}$
0	0	Toggling	Toggling
0	1	LOW	HIGH
1	0	Toggling	Toggling
1	1	HIGH	LOW

**Table 3B. Input Selection Table**

Selection SEL pin	Inputs
0	A2, $\overline{A2}$
1	A1, $\overline{A1}$

## Absolute Maximum Ratings

NOTE: Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

Item	Rating
Power Supply Voltage, $V_{DD}$	-0.5V to +3.6V
Input Voltage, $V_I$	-0.5V to +3.6V
Output Voltage, $V_O$ Not to exceed 3.6V	-0.5 to $V_{DD} + 0.5V$
Storage Temperature, $T_{STG}$	-65°C to 150°C
Junction Temperature, $T_J$	150°C

## Recommended Operating Range

Symbol	Description	Minimum	Typical	Maximum	Units
$T_A$	Ambient Operating Temperature	0	25	70	°C
$V_{DD}$	Internal Power Supply Voltage	2.3	2.5	2.7	V

## DC Electrical Characteristics

**Table 4A. LVDS Power Supply DC Characteristics<sup>(1)</sup>,  $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical <sup>(2)</sup>	Maximum	Units
$I_{DDQ}$	Quiescent $V_{DD}$ Power Supply Current	$V_{DD} = \text{Max.}$ , All Input Clocks = LOW <sup>(2)</sup> ; Output enabled			240	mA
$I_{TOT}$	Total Power $V_{DD}$ Supply Current	$V_{DD} = 2.7V$ ; $F_{REFERENCE}$ Clock = 450MHz			250	mA
$I_{PD}$	Total Power Down Supply Current	$\overline{PD} = \text{LOW}$			5	mA

NOTE 1. These power consumption characteristics are for all the valid input interfaces and cover the worst case conditions.

NOTE 2. The true input is held LOW and the complementary input is held HIGH.

**Table 4B. LVCMOS/LVTTL DC Characteristics<sup>(1)</sup>,  $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical <sup>(2)</sup>	Maximum	Units
$I_{IH}$	Input High Current	$V_{DD} = 2.7V$			$\pm 5$	$\mu A$
$I_{IL}$	Input Low Current	$V_{DD} = 2.7V$			$\pm 5$	$\mu A$
$V_{IK}$	Clamp Diode Voltage	$V_{DD} = 2.3V$ , $I_{IN} = -18mA$		-0.7	-1.2	V
$V_{IN}$	DC Input Voltage		-0.3		3.6	V
$V_{IH}$	DC Input High Voltage		1.7			V
$V_{IL}$	DC Input Low Voltage				0.7	V
$V_{THI}$	DC Input Threshold Crossing Voltage			$V_{DD}/2$		V
$V_{REF}$	Single-Ended Reference Voltage <sup>(3)</sup>	3.3V LVTTTL		1.65		V
		2.5V LVTTTL		1.25		V

NOTE 1. See *Recommended Operating Range* table.

NOTE 2. Typical values are at  $V_{DD} = 2.5V$ ,  $+25^\circ C$  ambient.

NOTE 3. For A[1:2] single-ended operation,  $\overline{A}[1:2]$  is tied to a DC reference voltage.

**Table 4C. Differential DC Characteristics<sup>(1)</sup>,  $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical <sup>(2)</sup>	Maximum	Units
$I_{IH}$	Input High Current	$V_{DD} = 2.7V$			$\pm 5$	$\mu A$
$I_{IL}$	Input Low Current	$V_{DD} = 2.7V$			$\pm 5$	$\mu A$
$V_{IK}$	Clamp Diode Voltage	$V_{DD} = 2.3V$ , $I_{IN} = -18mA$		-0.7	-1.2	V
$V_{IN}$	DC Input Voltage		-0.3		3.6	V
$V_{DIF}$	DC Differential Voltage <sup>(3)</sup>		0.1			V
$V_{CM}$	DC Common Mode Input Voltage <sup>(4)</sup>		0.05		$V_{DD}$	V

NOTE 1. See *Recommended Operating Range* table.

NOTE 2. Typical values are at  $V_{DD} = 2.5V$ ,  $+25^\circ C$  ambient.

NOTE 3.  $V_{DIF}$  specifies the minimum input differential voltage ( $V_{TR} - V_{CP}$ ) required for switching where  $V_{TR}$  is the "true" input level and  $V_{CP}$  is the "complement" input level. The DC differential voltage must be maintained to guarantee retaining the existing HIGH or LOW input. The AC differential voltage must be achieved to guarantee switching to a new state.

NOTE 4.  $V_{CM}$  specifies the maximum allowable range of  $(V_{TR} + V_{CP})/2$ .

**Table 4D. LVDS DC Characteristics<sup>(1)</sup>,  $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = 0^\circ C$  to  $70^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical <sup>(2)</sup>	Maximum	Units
$V_{OT(+)}$	Differential Output Voltage for the True Binary State		247		454	mV
$V_{OT(-)}$	Differential Output Voltage for the False Binary State		247		454	mV
$\Delta V_{OT}$	Change in $V_{OT}$ Between Complementary Output States				50	mV
$V_{OS}$	Output Common Mode Voltage (Offset Voltage)		1.125	1.2	1.375	V
$\Delta V_{OS}$	Change in $V_{OS}$ Between Complementary Output States				50	mV
$I_{OS}$	Outputs Short Circuit Current	$V_{OUT+}$ and $V_{OUT-} = 0V$		12	24	mA
$I_{OSD}$	Differential Outputs Short Circuit Current	$V_{OUT+} = V_{OUT-}$		6	12	mA

NOTE 1. See *Recommended Operating Range* table.

NOTE 2. Typical values are at  $V_{DD} = 2.5V$ ,  $+25^\circ C$  ambient.

## AC Electrical Characteristics

**Table 5A. HSTL Differential Input AC Characteristics,  $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = 0^\circ C$  to  $70^\circ C$** 

Symbol	Parameter	Value	Units
$V_{DIF}$	Input Signal Swing <sup>(1)</sup>	1	V
$V_X$	Differential Input Signal Crossing Point <sup>(2)</sup>	750	mV
$D_H$	Duty Cycle	50	%
$V_{THI}$	Input Timing Measurement Reference Level <sup>(3)</sup>	Crossing Point	V
$t_R / t_F$	Input Signal Edge Rate <sup>(4)</sup>	2	V/ns

NOTE 1. The 1V peak-to-peak input pulse level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. This device meets the  $V_{DIF}$  (AC) specification under actual use conditions.

NOTE 2. A 750mV crossing point level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. This device meets the  $V_X$  specification under actual use conditions.

NOTE 3. In all cases, input waveform timing is marked at the differential cross-point of the input signals.

NOTE 4. The input signal edge rate of 2V/ns or greater is to be maintained in the 20% to 80% range of the input waveform.

**Table 5B. eHSTL AC Differential Input Characteristics,  $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = 0^\circ C$  to  $70^\circ C$** 

Symbol	Parameter	Value	Units
$V_{DIF}$	Input Signal Swing <sup>(1)</sup>	1	V
$V_X$	Differential Input Signal Crossing Point <sup>(2)</sup>	900	mV
$D_H$	Duty Cycle	50	%
$V_{THI}$	Input Timing Measurement Reference Level <sup>(3)</sup>	Crossing Point	V
$t_R / t_F$	Input Signal Edge Rate <sup>(4)</sup>	2	V/ns

NOTE 1. The 1V peak-to-peak input pulse level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. This device meets the  $V_{DIF}$  (AC) specification under actual use conditions.

NOTE 2. A 900mV crossing point level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. This device meets the  $V_X$  specification under actual use conditions.

NOTE 3. In all cases, input waveform timing is marked at the differential cross-point of the input signals.

NOTE 4. The input signal edge rate of 2V/ns or greater is to be maintained in the 20% to 80% range of the input waveform.

**Table 5C. LVEPECL (2.5V) and LVPECL (3.3V) Differential Input AC Characteristics,  $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = 0^\circ C$  to  $70^\circ C$** 

Symbol	Parameter		Maximum	Units
$V_{DIF}$	Input Signal Swing <sup>(1)</sup>		732	mV
$V_X$	Differential Input Cross Point Voltage <sup>(2)</sup>	LVEPECL	1082	mV
		LVPECL	1880	mV
$D_H$	Duty Cycle		50	%
$V_{THI}$	Input Timing Measurement Reference Level <sup>(3)</sup>		Crossing Point	V
$t_R / t_F$	Input Signal Edge Rate <sup>(4)</sup>		2	V/ns

NOTE 1. The 732mV peak-to-peak input pulse level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. This device meets the  $V_{DIF}$  (AC) specification under actual use conditions.

NOTE 2. A 1082mV LVEPECL (2.5V) and 1880mV LVPECL (3.3V) crossing point level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. This device meets the  $V_X$  specification under actual use conditions.

NOTE 3. In all cases, input waveform timing is marked at the differential cross-point of the input signals.

NOTE 4. The input signal edge rate of 2V/ns or greater is to be maintained in the 20% to 80% range of the input waveform.

**Table 5D. LVDS Differential Input AC Characteristics,  $T_A = 0^\circ C$  to  $70^\circ C$** 

Symbol	Parameter		Maximum	Units
$V_{DIF}$	Input Signal Swing <sup>(1)</sup>		400	mV
$V_X$	Differential Input Cross Point Voltage <sup>(2)</sup>		1.2	V
$D_H$	Duty Cycle		50	%
$V_{THI}$	Input Timing Measurement Reference Level <sup>(3)</sup>		Crossing Point	V
$t_R / t_F$	Input Signal Edge Rate <sup>(4)</sup>		2	V/ns

NOTE 1. The 400mV peak-to-peak input pulse level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. This device meets the  $V_{DIF}$  (AC) specification under actual use conditions.

NOTE 2. A 1.2V crossing point level is specified to allow consistent, repeatable results in an automatic test equipment (ATE) environment. This device meets the  $V_X$  specification under actual use conditions.

NOTE 3. In all cases, input waveform timing is marked at the differential cross-point of the input signals.

NOTE 4. The input signal edge rate of 2V/ns or greater is to be maintained in the 20% to 80% range of the input waveform.

**Table 5E. AC Differential Input Characteristics<sup>(1)</sup>,  $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = 0^\circ C$  to  $70^\circ C$** 

Symbol	Parameter	Minimum	Typical	Maximum	Units
$V_{DIF}$	AC Differential Voltage <sup>(2)</sup>	0.1		3.6	V
$V_X$	Differential Input Cross Point Voltage	0.05		$V_{DD}$	V
$V_{CM}$	Common Mode Input Voltage Range <sup>(3)</sup>	0.05		$V_{DD}$	V
$V_{IN}$	Input Voltage	-0.3		3.6	V

NOTE 1. The output will not change state until the inputs have crossed and the minimum differential voltage range defined by  $V_{DIF}$  has been met or exceeded.

NOTE 2.  $V_{DIF}$  specifies the minimum input voltage ( $V_{TR} - V_{CP}$ ) required for switching where  $V_{TR}$  is the “true” input level and  $V_{CP}$  is the “complement” input level. The AC differential voltage must be achieved to guarantee switching to a new state.

NOTE 3.  $V_{CM}$  specified the maximum allowable range of  $(V_{TR} + V_{CP}) / 2$ .

**Table 5F. AC Characteristics<sup>(1,5)</sup>,  $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = 0^\circ C$  to  $70^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$t_{sk(o)}$	Same Device Output Pin-to-Pin Skew <sup>(2)</sup>				50	ps
$t_{sk(p)}$	Pulse Skew <sup>(3)</sup>				125	ps
$t_{sk(pp)}$	Part-to-Part Skew <sup>(4)</sup>				300	ps
$t_{pLH}$	Propagation Delay, Low-to-High	A Crosspoint to Qn, $\overline{Qn}$ Crosspoint		1.25	1.75	ns
$t_{pHL}$	Propagation Delay, High-to-Low			1.25	1.75	ns
$f_o$	Frequency Range <sup>(6)</sup>				450	MHz
$t_{PGE}$	Output Gate Enable Crossing V <sub>THI</sub> -to-Qn/ $\overline{Qn}$ Crosspoint				3.5	ns
$t_{PGD}$	Output Gate Enable Crossing V <sub>THI</sub> -to-Qn/ $\overline{Qn}$ Crosspoint Driven to Designated Level				3.5	ns
$t_{PWRDN}$	PD Crossing V <sub>THI</sub> -to-Qn = V <sub>DD</sub> , $\overline{Qn} = V_{DD}$				100	$\mu S$
$t_{PWRUP}$	Output Gate Disable Crossing V <sub>THI</sub> to Qn/ $\overline{Qn}$ Driven to Designated Level				100	$\mu S$
$t_R / t_F$	Output Rise/Fall Time <sup>(6)</sup>	20% to 80%	125		600	ps

NOTE. Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE 1. AC propagation measurements should not be taken within the first 100 cycles of startup.

NOTE 2. Skew measured between Crosspoint of all differential output pairs under identical input and output interfaces, transitions and load conditions on any one device.

NOTE 3. Skew measured is the difference between propagation delay times  $t_{pHL}$  and  $t_{pLH}$  of any differential output pair under identical input and output interfaces, transitions and load conditions on any one device.

NOTE 4. Skew measured is the magnitude of the difference in propagation times between any single differential output pair of two devices, given identical transitions and load conditions at identical V<sub>DD</sub> levels and temperature.

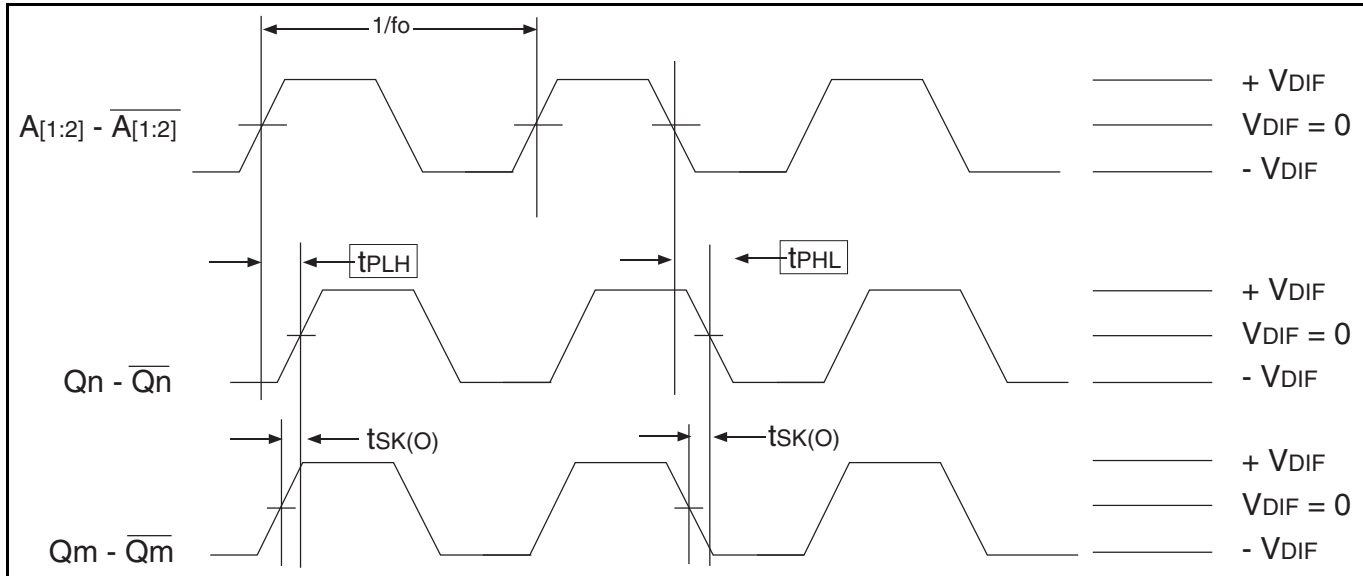
NOTE 5. All parameters are tested with a 50% input duty cycle.

NOTE 6. Guaranteed by design but not production tested.



## Differential AC Timing Waveforms

### Output Propagation and Skew Waveforms



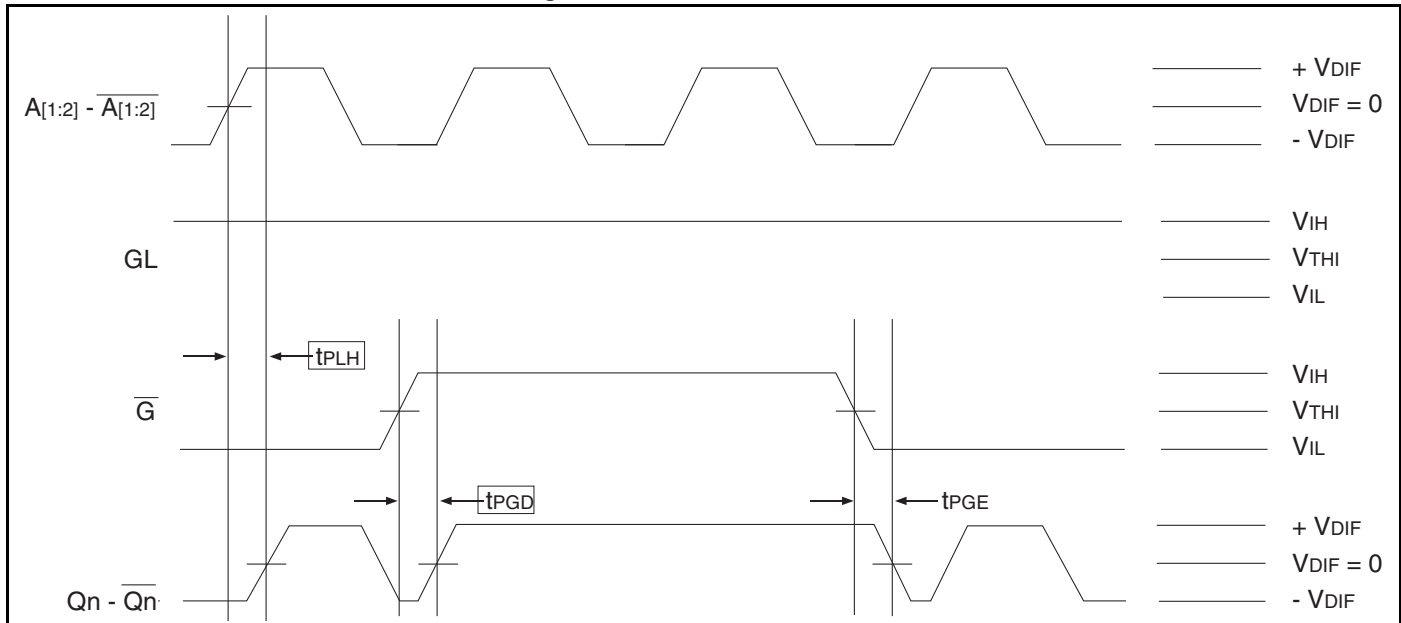
NOTE 1: Pulse skew is calculated using the following expression:

$$t_{sk(p)} = |t_{p_{HL}} - t_{p_{LH}}|$$

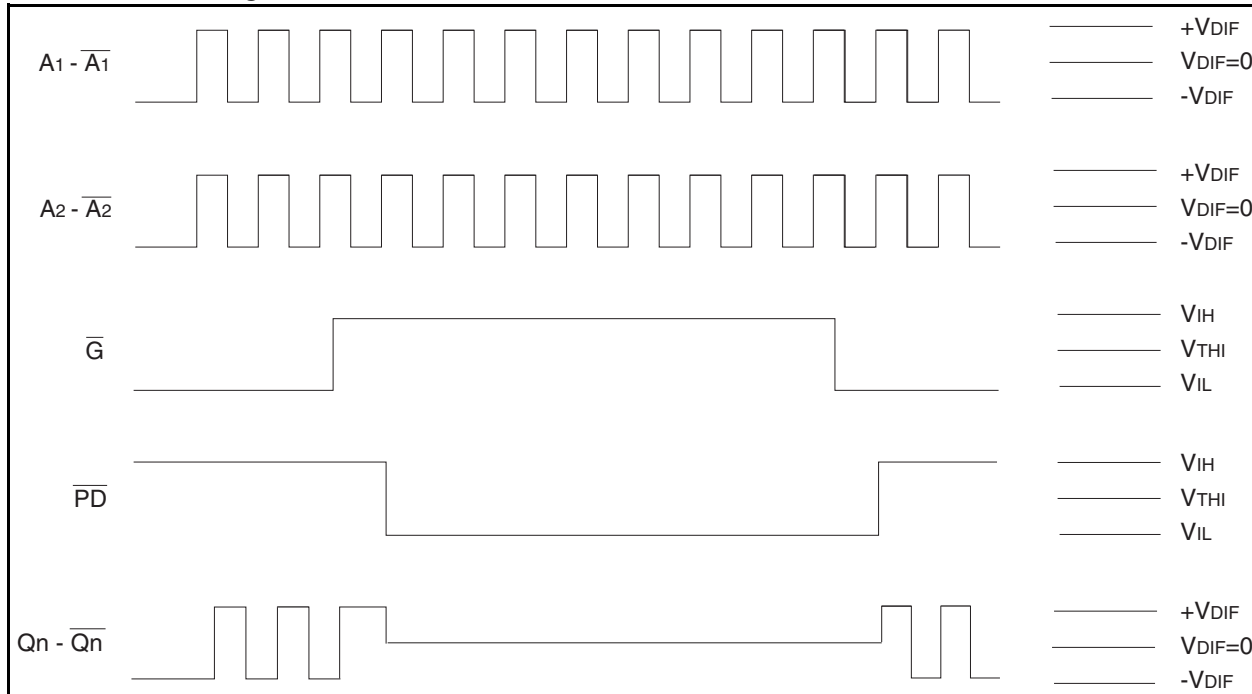
Note that the  $t_{p_{HL}}$  and  $t_{p_{LH}}$  shown above are not valid measurements for this calculation because they are not taken from the same pulse.

NOTE 2: AC propagation measurements should not be taken within the first 100 cycles of startup.

### Differential Gate Disabled/Endable Showing Runt Pulse Generation



NOTE 1: As shown, it is possible to generate runt pulses on gate disable and enable of the outputs. It is the user's responsibility to time the  $\overline{G}$  signal to avoid this problem.

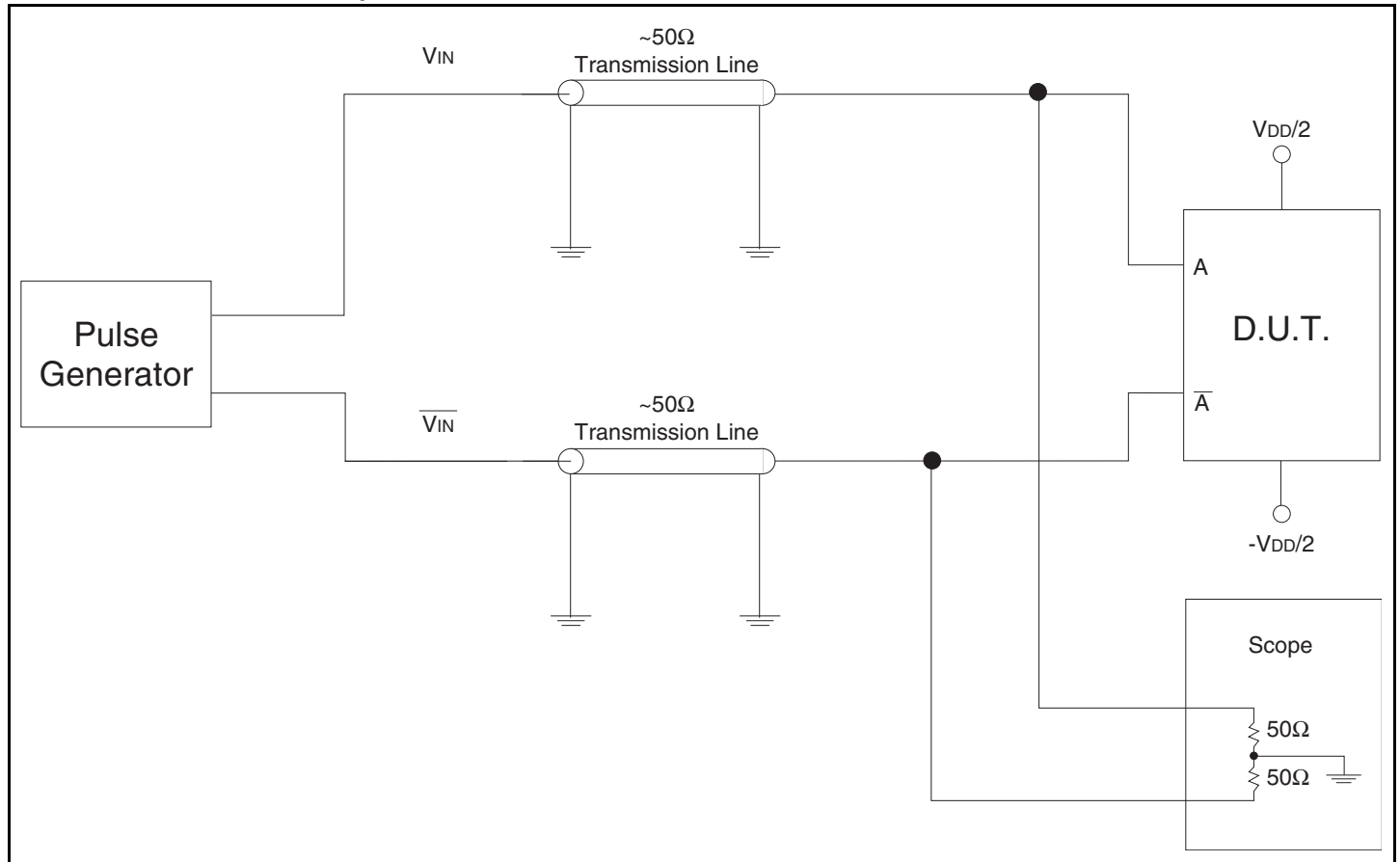
**Power Down Timing**


NOTE 1: It is recommended that outputs be disabled before entering power-down mode. It is also recommended that the outputs remain disabled until the device completes power-up after asserting  $\overline{PD}$ .

NOTE 2: The *Power Down Timing* diagram assumes that  $GL$  is HIGH.

NOTE 3: It should be noted that during power-down mode, the outputs are both pulled to  $V_{DD}$ . In the *Power Down Timing* diagram this is shown when  $Qn/\overline{Qn}$  goes to  $V_{DIF} = 0$ .

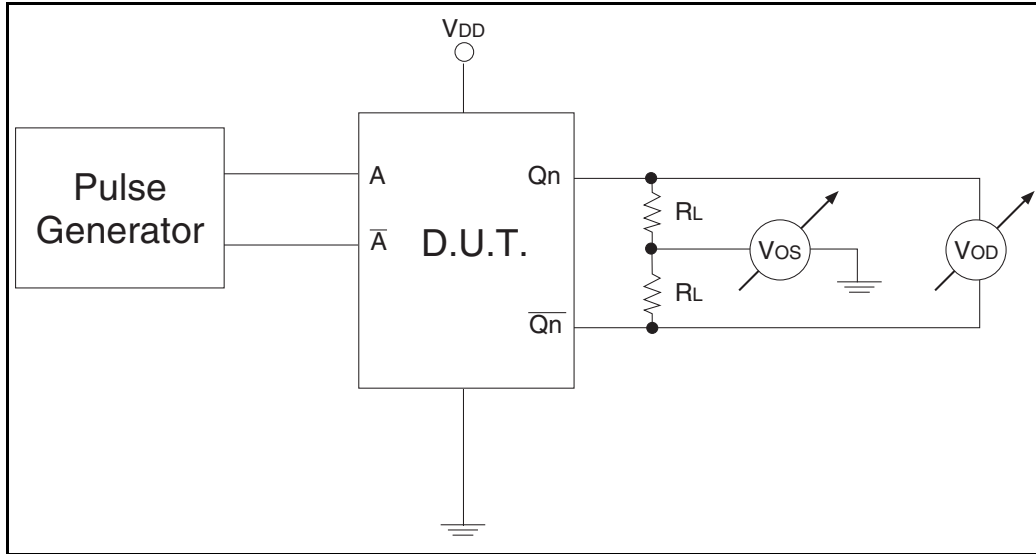
### Test Circuit for Differential Input



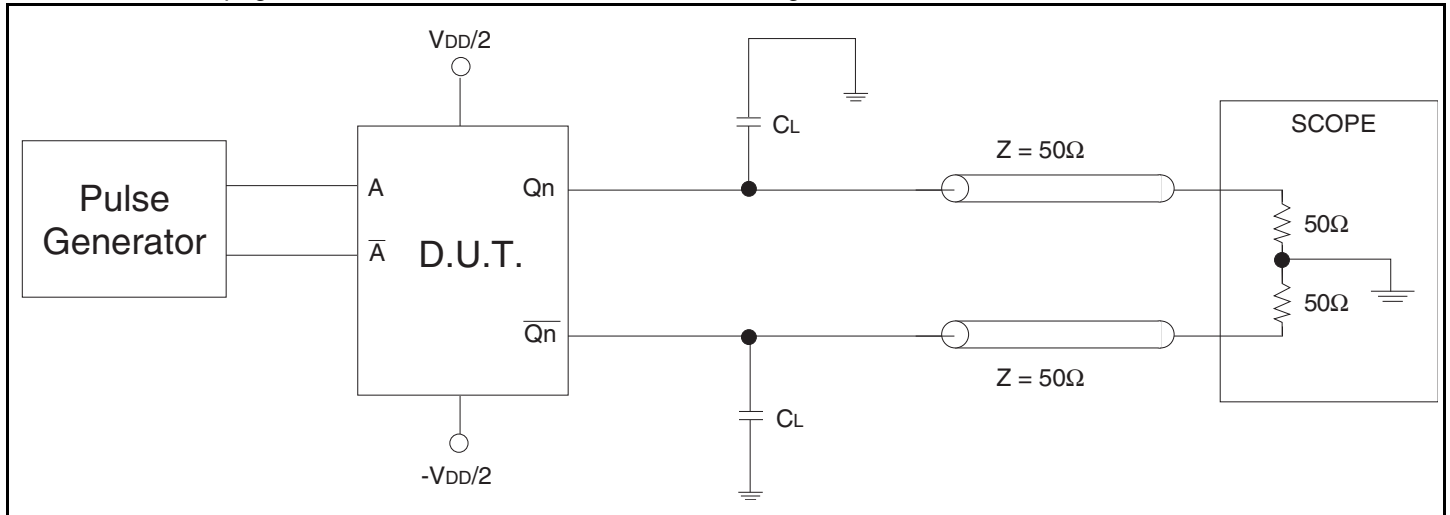
**Table 6A. Differential Input Test Conditions**

Symbol	$V_{DD} = 2.5V \pm 0.2V$	Unit
$V_{THI}$	Crossing of A and $\overline{A}$	V

**Test Circuit for DC Outputs and Power Down Tests**



**Test Circuit for Propagation, Skew, and Gate Enable/Disable Timing**



**Table 6B. Differential Input Test Conditions**

Symbol	$V_{DD} = 2.5V \pm 0.2V$	Unit
$C_L$	$0^{(1)}$	pF
	$8^{(1,2)}$	pF
$R_L$	50	$\Omega$

NOTE 1: Specifications only apply to “Normal Operations” test condition. The  $T_{IA}/E_{IA}$  specification load is for reference only.

NOTE 2: The scope inputs are assumed to have a 2pF load to ground.  $T_{IA}/E_{IA} - 644$  specifies 5pF between the output pair. With  $C_L = 8pF$ , this gives the test circuit appropriate 5pF equivalent load.

## Package Outline and Package Dimensions

### Package Outline - G Suffix for 24 Lead TSSOP

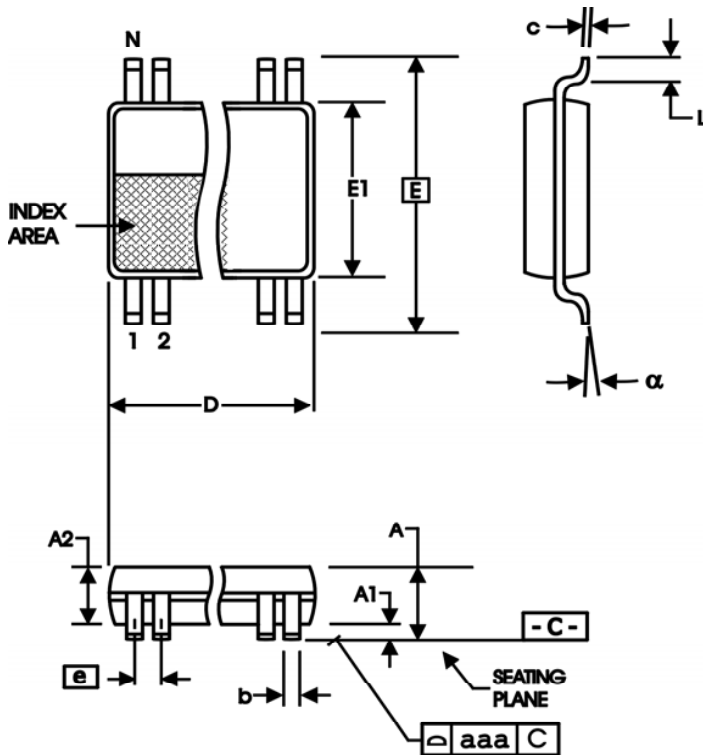


Table 7. Package Dimensions

All Dimensions in Millimeters		
Symbol	Minimum	Maximum
N	24	
A		1.20
A1	0.5	0.15
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	7.70	7.90
E	6.40 Basic	
E1	4.30	4.50
e	0.65 Basic	
L	0.45	0.75
$\alpha$	0°	8°
aaa		0.10

Reference Document: JEDEC Publication 95, MO-153

## Ordering Information

Table 8. Ordering Information

XXXXX	XX	X	
Device Type	Package	Process	
			0°C to + 70°C (Commercial)
			PGG
			TSSOP - Green
			5T9304
			2.5V LVDS 1:4 Glitchless Clock Buffer Terabuffer™ II

## Revision History Sheet

Rev	Table	Page	Description of Change	Date
A		1	Not Recommended For New Designs	5/16/13
A	T8	14	Ordering Information - Removed Leaded Devices PDN N-13-11 Updated data sheet format	3/11/15
A	T8	14	Ordering Information - Corrected Commercial temperature. Removed NRND from the data sheet.	5/13/15



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